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ALGAE
Biodiversity, Influencial Parameters and the Applications
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GAANTY PRAGAS MANIAM

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ALGAE

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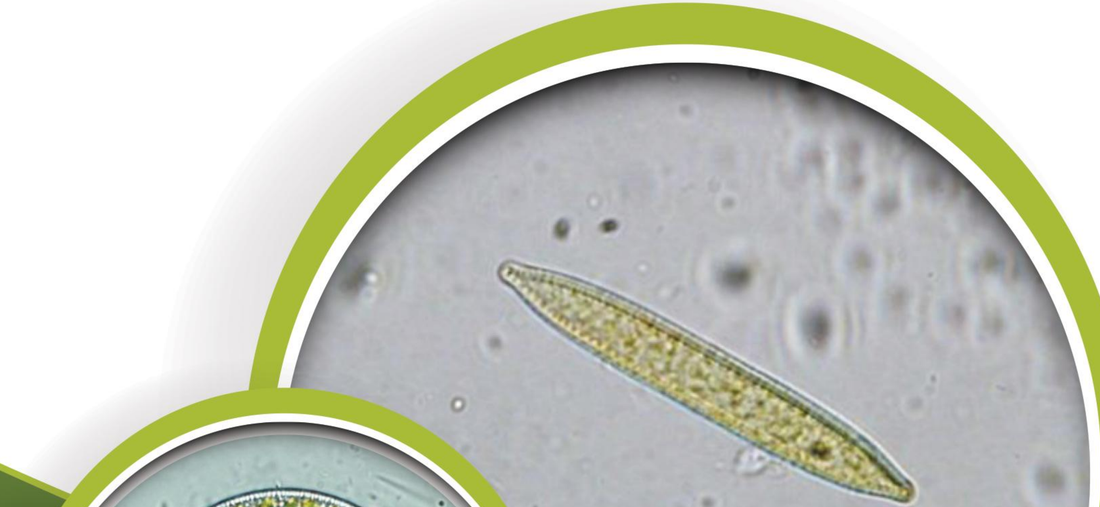

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CONTENTS

LIST OF SYMBOLS

%	percentage
°C	degree Celsius
d^{-1}	per day
CO_2	Carbon dioxide
pH	Hydrogen Ion Concentration
A	Absorbance
L	Litre
m	Metre
µg	Microgram
mg / ml	Milligram per millilitre
hr	Hour
g	Gram
mm	Millimetre
cm	Centimetre
±	Uncertainty
°N	North Latitude
°E	East Longitude
M	Molarity
cm-1	per centimetre
ml	Millilitre
Min	Minute

LIST OF ABBREVIATIONS

µg	microgram
µm	micrometre
°C/min	Degree Celcius per minute
A	Absorbance
AFM	Atomic Force Microscopy
$AgNO_3$	Silver Nitrate
AgNPs	Silver Nanoparticles
Anova	Analysis of Variance
ATCC	American type culture collection
BG	Blue Green
BHT	butylatedhydroxytoluene
C	Carbon
$CaCl_2$	Calcium chloride
CH_4	Methane
Chl a	Chlorophyll a
Chl	Chlorophyll
Cm	Centimetre
$Cu(NO_3)_2$	Copper nitrate
CO_2	Carbon dioxide
COD	Chemical oxygen demand
$CuSO_4$	Copper sulphate
DCW	Dry cell weight
DLS	Dynamic Light Scattering
DPPH	2,2-diphenyl-1-picrylhydrazyl
E	East
E.cottonii	Eucheuma cottonii
EDX	Energy Dispersive X-ray Spectrophotometer

EFB	Empty fruit bunches
FAME	Fatty Acid Methyl Ester
FE SEM	Field Emission Scanning Electron Microscope
FFB	Fresh fruit bunches
FRAP	Ferric Reducing Antioxidant Power
FT-IR	Fourier Transform Infrared Spectroscopy
g	G-force / Relative Centrifugal Force
g/L	Gram per litre
GAE	Gallic Acid Equivalent
GC	Gas Chromatography
GC-FID	Gas Chromatography – Flame Ionization Detector
GC-MS	Gas Chromatography-Mass Spectrometry
GT	Grand Total
H	Hydrogen
H_2S	Hydrogen sulfide
H_3BO_3	Boric acid
HCl	Hydrochloric acid
hr	Hour
IC_{50}	Fifty percent inhibitor concentration
K_2HPO_4	Dipotassium hydrogen phosphate
Kg	Kilogram
Km	Kilometer
L	Litre
Lad	Latitude
LM	Light microscope
Long	Longitude
m	Metre
M	Molarity
mg	Milligram
mg/L	Milligram per liter
$MgSO_4$	Magnesium sulphate
MIC	Minimal Inhibitory Concentration
min	minutes
ml	Millilitre
$MnCl_2$	Manganese chloride
Mol.	Molecular Formula
MPOB	Malaysian Palm Oil Board

MSD	Mass Spectrometer Detector
MW	Molecular weight
N	Nitrogen
N	Number of replicate
Na_2CO_3	Sodium Carbonate
Na_2EDTA	Disodium ethylenediamine tetraacetate
Na_2MoO_4	Sodium molybdate
NaCl	Sodium chloride
$NaNO_3$	Sodium nitrate
NaOH	Sodium hydroxide
NaOH	Sodium hydroxide
ND	Not detected
NIST	National Institute of Science and Technology
nm	nanometre
NMR	Nuclear Magnetic Resonance
NP	nanoparticle
NR	Nile red
O	Oxygen
OD	Optical Density
P	Phosphorus
pH	Hydrogen Ion Concentration
POME	Palm oil mill effluent
PUFAs	Polyunsaturated Fatty Acid
r	Error
R&D	Research and Development
ROS	Reactive oxygen species
rpm	Revolutions per minute
Rt	Retention Time
s	Second
SE	Soxhlet extraction
SEM	Scanning Electron Microscopy
Si	Silicon
Sp.	Species
SPSS	Statistical Program for Social Sciences
TAGs	Triglycerides
TEM	Transmission Electron Microscopy
TPC	Total Phenolic Contents

TPTZ	2,4,6-Tri(2-pyridyl)-1,3,5-triazine
UMP	Universiti Malaysia Pahang
UV-Vis	Ultraviolet-Visible Spectrophotometer
V	Volume
$ZnSO_4$	Zinc sulphate
µl	Microlitre
µm	Micrometre

PREFACE

Research on Algae is now a more important subject in this era of marine biology and biotechnology. Marine biologists are trying to understand the function of algae and its uses in all aspects of biological and biomedical approaches. Finding algal potentials is correlated with identification of microalgae in a particular environment for its antibacterial activities, antioxidant activities, nutrient enrichments, synthesizing nano particles, separation of bioactive compounds and secondary metabolites, identification of polysaccharides, biodiesel production, identification of toxin producing microalgae and lipids production for various health supplements and so forth which can be corroborated with algae observations. This text book on algae deals with the basic information and ideas on how the algae research started by young researchers from the local freshwater, estuary, mangroves and marine environments to find the potential of algal research for the current and future knowledge.

The source for inspiration for writing this book is owing to the superb research that the author received from both Faculty of Industrial Sciences & Technology and Central Laboratory at University Malaysia Pahang, Malaysia. The study areas of Kuantan and Pekan coastal region have numerous number of micro and macro algae assembled in all seasons. Hence, the text book is a potential guide to all

ranges of researchers for all kinds of advanced study of algae to be conducted in the future.

The Textbook of Algae describes the methodology of collection, isolation, identification, mass cultivation and most of the instruments handling methods for the separation of bioactive potentials, separation of polysaccharides, synthesis of nanoparticles and biodiesel productions.

All in all, my sincerest thanks to all of my Colleagues, Science Officers, Postgraduates and Undergraduates in the Faculty of Industrial Sciences & Technology and Central Laboratory for their continuous support in data collections and the use of Scanning Electron microscope as well as other instruments throughout the studies.

Natanamurugaraj Govindan

GLOSSARY

A

Abiotic factors- A non-living chemical or physical factor in the environment, such as soil, pH, forest fire.

Absorbance Spectroscopy- Commonly referred to as spectrophotometry, is the analytical technique based on measuring the amount of light absorbed by a sample at a given wavelength.

Adaptability -the ability to change or be changed in order to fit or work better in some situation or for some purpose.

Aeration- the process by which air is circulated through, mixed with or dissolved in a liquid or substance.

Agglomerated - to gather into a ball, mass or cluster.

Agrochemical- a chemical used in agriculture, such as a pesticide or a fertilizer.

Algal biomass- the amount of algae in a water body at a given time.

Alginate- alginate is a salt of alginic acid

ANOVA analysis- a collection of statistical models used to analyze the differences among group means and their associated procedures.

Anthropogenic threats -of or resulting from the influence of human beings on nature.

Antiadhesive-any substance or compound that prevents adhesion.

Antibacterial Anything that destroys bacteria growth/ ability to reproduce

Antibacterial activity- activities that destroy bacteria or suppress their growth or their ability to reproduce.

Anti-inflammatory agents a group of medicines that have anti-inflammatory, analgesic (relieve pain) and antipyretic (lower temperature) effects.

Antioxidant- a substance that is added to food and other products to prevent harmful chemical reactions in which oxygen is combined with other substances.

Antipeptic- the act of inhibiting pepsin.

Antiproliferative- of or relating to a substance used to prevent or retard the spread of cells.

Antiviral- An agent that kills a virus or that suppresses its ability to replicate and, hence, inhibits its capability to multiply and reproduce.
Apertures -a whole or small opening in something.
Archipelago- a group of islands. A sea or stretch of water containing many islands.
Arcuate- curved like a bow.
Argyria/ Argyrosis- a condition caused by excessive exposure to chemical compounds of the element silver, or to silver dust.
Asbestos- a heat-resistant fibrous silicate mineral that can be woven into fabrics, and is used in fire-resistant and insulating materials such as brake linings.
Assimilation-the absorption and digestion of food or nutrients by the body or any biological system.
Atherosclerosis a disease in which plaque builds up inside your arteries.
Atomic Force Microscopy (AFM)-A form of scanning probe microscopy, is a technique where a cantilever with a sharp tip is systematically scanned across a sample (biological or material) surface to produce a nanometre-resolution topographic map.

B

Benign- a condition, tumor, or growth that is not cancerous.
Benthic- relating to, or occurring at the bottom of a body of water.
Bio monitoring the measurement of the body burden of toxic chemical compounds.
Biocide- a poisonous substance, especially a pesticide.
Biomass- the amount of algae in a water body at a given time
Biomass -total mass of organisms in a given area or volume.
Bio-oils is a synthetic fuel under investigation as substitute for petroleum.
Biotic factors- any living component that affects the population of another organism, or the environment.
Biotin- a colorless crystalline growth vitamin $C_{10}H_{16}N_2O_3S$ of the vitamin B complex found especially in yeast, liver and egg yolk.
Brackish- somewhat salty.
B-carotene -an accessory carotenoid pigment lacking oxygen that occurs in major algal group; the source of provitamin A

C

Calyptra- a hood-like structure in a plant; especially: haploid tissue forming a membranous hood over the capsule in a moss.
Capitate- forming a head.

Carbon sequestration- the burial of calcium carbonate or organic carbon such that these materials are not readily converted back to atmospheric carbon dioxide.
Carcinogenesis- the initiation of cancer formation.
Carotenoid- any of various usually yellow to red pigments (as carotenes) found widely in plants and animals and characterized chemically by a long aliphatic polyene chain composed of eight isoprene units.
Carotenoids- any of a class of mainly yellow, orange, or red fat-soluble pigments, including carotene, which give colour to plant parts such as ripe tomatoes and autumn leaves.
Carrageenan- a substance extracted from red and purple seaweeds, consisting a mixture of polysaccharide.
Cell dry weight- the weight left when the cells water content has been removed by heating.
Cellulose- an insoluble substance that is the main constituent of plant cell walls and of vegetable fibers such as cotton. It is a polysaccharide consisting of chains of glucose monomers.
Central composite design (CCD) - a factorial or fractional factorial design with center points, augmented with a group of axial points (also called star points) that let you estimate curvature.
Centrifugation -a machine using centrifugal force for separating substances of different densities, for removing moistures, or for simulating gravitational effects.
Chlorophyll -a pigment in green plants that helps transfer light into energy.
Chlorophyll *a*- the photosynthetic pigment that forms the reaction center of photosystems I and II in most algae and land plants.
Chlorophyll- the green substance in plants that makes it possible for them to make food from carbon dioxide and water.
Chromatophore- the organelle of photosynthesis in photosynthetic bacteria.
Climatic factors - include sunlight, humidity, temperature, atmosphere, etc.
CO_2 fixation -conversion process of inorganic carbon to organic compounds by living organisms.
Colonies -A cluster of identical cells on the surface of a solid medium, usually derived from a single parent cell, as in bacterial colony.
Conventional crops -synthetic chemicals are made use of to increase the growth of cultivation in farming.
Cyanobacteria- is a phylum of bacteria that obtain their energy through photosynthesis

D

Death phase- The final growth phase, during which nutrients have been depleted and cell number decreases.

Deproteinization- an act or process of removing protein.

Detoxification- the physiological or medicinal removal of toxic substances from a living organism, including the human body, which is mainly carried out by the liver.

Diatoms- algae with distinctive, transparent cell walls made of silicon dioxide hydrated with a small amount of water.

Diatoms -any of a class (Bacillariophyceae) of minute planktonic unicellular or colonial algae with silicified skeletons that form diatomaceous earth.

Discoid -flat and circular like a disk.

DPPH- is a common abbreviation for the organic chemical compound 2,2-diphenyl-1-picrylhydrazyl. It is a dark-colored crystalline powder composed of stable free-radical molecules.

Dynamic Light Scattering -(DLS)-A technique in physics that can be used to determine the size distribution profile of small particles in suspension or polymers in solution.

E

Eicosapentaenoic acid -a polyunsaturated fatty acid found especially in algae oils.

Epiphytes- A plant that grows on another plant and depends on it for support but not food.

Estuaries -areas where rivers flow into seas.

Eutrophication-excessive richness of nutrients in a lake or other body of water, frequently due to runoff from the land, which causes a dense growth of plant life and death of animal life from lack of oxygen.

Extraction the action of taking out something, especially using effort or force.

F

Fatty acid profile -measures the percentage of fatty acids in algae biomass

Fhysolaminaran- is a storage polysaccharide typically found in photosynthetic heterokonts

Field Emission Scanning Electron Microscope-An analytical technique used in materials science to investigate molecular surface structures and their electronic properties.

Filaments - a thin thread or hair.

Flame ionization detector (FID) - a scientific instrument that measures the concentration of organic species in a gas stream. It is frequently used as a detector in gas chromatography.
Flavonoids- any of a large class of plant pigments having a structure based on or similar to that of flavone.
Flocculation- The process by which individual particles of clay aggregate into clot like masses or precipitate into small lumps.
Flow cytometry- a laser- or impedance-based, biophysical technology employed in cell counting, cell sorting, biomarker detection and protein engineering, by suspending cells in a stream of fluid and passing them by an electronic detection apparatus.
Fluorescence -the visible or invisible radiation emitted by certain substances.
Folin–Ciocalteu reagent is a mixture of phosphomolybdate and phosphotungstate used for the colorimetric in vitro assay of phenolic and polyphenolic antioxidants.
Frustule -the hard and porous cell wall or external layer of diatoms.
Fucoidan- is a sulfated polysaccharide found mainly in various species of brown algae and brown seaweed.
Fucoxanthin- a brown carotenoid pigment occurring in brown algae.
Furfural- is a heterocyclic aldehyde, with the ring structure shown at right.

G
Gas-Chromatography Analysis- analytical chemistry for separating and analyzing compounds that can be vaporized without decomposition flame ionization detector.
Glycosidic bond- a type of covalent bond that joins a carbohydrate (sugar) molecule to another group, which may or may not be another carbohydrate.
Gram-negative bacteria- a group of bacteria that do not retain the crystal violet stain used in the Gram staining method of bacterial differentiation.
Gram-positive bacteria- bacteria that give a positive result in the Gram stain test. Gram-positive bacteria take up the crystal violet stain used in the test, and then appear to be purple-coloured when seen through a microscope.
Gravimetric method -used in analytical chemistry for the quantitative determination of an analyte (the ion being analyzed) based on its mass.
Growth rate- at which the number of organisms in a population increases.
Growth rate -percentage change of a specific variable within a specific time period, given a certain context.

H

Hemicellulose- any of a class of substances that occur as constituents of the cell walls of plants and are polysaccharides of simpler structure than cellulose.

Hemocytometer- an instrument for counting blood cells.

Heterogeneity- the quality or state of being heterogeneous; composition from dissimilar parts; disparateness.

Hormogonia-portions of the filaments in many cyanobacteria that become detached as reproductive bodies.

Hyaline- a transparent or nearly so and usually homogenous.

Hypersaline -excessively salty.

I

Illumination -lighting or light.

Inhibition -the act of preventing or slowing the activity or occurrence of something.

Inhibition zone- The clear region around the paper disc saturated with an antimicrobial agent on the agar surface.

L

Lag phase- the period when the bacteria are adjusting to the environment.

Laminarin- a storage glucan found in brown algae.

Light intensity the brightness of light. The rate at which the energy from the light is received at a unit of surface.

Light scattering -a form of scattering in which light in the form of propagating energy is scattered.

Lignin- a complex organic polymer deposited in the cell walls of many plants, making them rigid and woody.

Lignocellulosic biomass- an important component of the major food crops; it is the non-edible portion of the plant, which is currently underutilized, but could be used for biofuel production.

Limit of Detection (LOD)-The lowest quantity or concentration of a component that can be reliably detected with a given analytical method.

Lipophilic- tending to combine with or dissolve in lipids or fats.

Log phase- (sometimes called the logarithmic phase or the exponential phase) is a period characterized by cell doubling.

Lyophilization - drying is a process in which water is removed from a product after it is frozen

M

Marshes -areas of soft, wet land that has many grasses and other plants.

Mass transfer rate -time taken for the net movement of mass from one location to another.
Microphytes- or microalgae are microscopic algae, typically found in freshwater and marine systems living in both the water column and sediment. They are unicellular species which exist individually, or in chains or groups.
Micro-plate reader -an instruments which are used to detect biological, chemical or physical events of samples in micro titer plates
Microzooplankton- key components of marine food webs. Their grazing significantly affects primary producers and usually exceeds that of mesozooplankton.
Moniliform -jointed or constricted at regular intervals so as to resemble a string of beads.
Morphological branch of biology dealing with the form and structure of organisms.

N
Nanoparticles- particles between 1 and 100 nanometers in size. In nanotechnology, a particle is defined as a small object that behaves as a whole unit with respect to its transport and properties.
Nanotechnology- the branch of technology that deals with dimensions and tolerances of less than 100 nanometers, especially the manipulation of individual atoms and molecules.
Nomenclature -a system of names for things especially in science.

O
Oceanographers- a special kind of scientist who studies the ocean.
Oligodynamic-the effect as a toxic effect of metal ions on living cells, algae, molds, spores, fungi, viruses, prokaryotic and eukaryotic microorganisms, even in relatively low concentrations.
Optical density the logarithmic ratio of the intensity of transmitted light to the intensity of the incident light passing through the substance.
Optical microscope- a microscope using visible light, typically viewed directly by the eye.
Optimization- the action of making the best or most effective use of a situation or resource.
Oscillatory- to move in one direction and then back again many times.
Osmotic stress- a sudden change in the solute concentration around a cell, causing a rapid change in the movement of water across its cell membrane.
Ovoid- resembling an egg in shape.
Oxidation- terms of the transfer of oxygen, hydrogen and electrons.

P

Pelagic- relating to the open sea.

Periphyton -organisms (as some algae) that live attached to underwater surfaces.

Peroxidation- the oxidative degradation of lipids. It is the process in which free radicals "steal" electrons from the lipids in cell membranes, resulting in cell damage.

Phlorotannins -a type of tannins found in brown algae such as kelps and rockweeds or sargassacean species.

Pholorotannins- are a type of tannins found in brown algae such as kelps and rockweeds or sargassacean species, and also in some red algae.

Photochemical phase- the light dependent phase of photosynthesis as it can occur only in the presence of light.

Photo-inhibition- light-induced reduction in the photosynthetic capacity of a plant, alga or cyanobacteria.

Photons- tiny particles of light or electromagnetic radiation.

Photosynthetic efficiency- the fraction of light energy converted into chemical energy during photosynthesis in plants and algae.

Photo-system- a biological mechanism in plants by which chlorophyll absorbs light energy for photosynthesis.

Phytoplankton- floating or swimming microscopic algae.

Plastids -any of various cytoplasmic organelles (as an amyloplast or chloroplast) of photosynthetic cells that serve in many cases as centers of special metabolic activities

Polyphenol -a compound containing more than one phenolic hydroxyl group

POME - (Palm Oil Mill Effluent) highly polluting oily waste water due to palm oil processing, known as POME.

Pre-cultivation- technique for microorganisms exhibiting overflow metabolism is presented.

Prehistoric plant - various groups of plants that lived before recorded history.

Primary metabolites- is a kind of metabolite that is directly involved in normal growth, development, and reproduction. It usually performs a physiological function in the organism.

Protozoa- Any of a large group of one-celled organisms (called protists) that live in water or as parasites.

Protrusion -the act of sticking out or the condition of something that sticks out.

Punctate-characterized by dots or points.

Q

Quantum sensor- high accuracy sensor to measure photo synthetically active radiation.

R

Rancidification- the product of which can be described as rancidity, is the process which causes a substance to become rancid that is, having a rank, unpleasant smell or taste.

Raphe -the median line or slit of the valve of certain diatoms.

Reactive nitrogen species (RNS) - are a family of antimicrobial molecules derived from nitric oxide and superoxide

Reactive oxygen species (ROS) - are chemically reactive chemical species containing oxygen.

Retention -the ability to keep extra liquid, heat, etc. inside the body.

Retention time- a measure of the time taken for a solute to pass through a chromatography column. It is calculated as the time from injection to detection.

Retention time- is a measure of the time taken for a salute to pass through a chromatography column

Riparian zones- the interface between land and a river or stream. Riparian is also the proper nomenclature for one of the fifteen terrestrial biomes of the earth.

S

Saponins- a toxic compound that is present in soapwort and makes foam when shaken with water.

Scanning electron microscope-an electron microscope in which the surface of a specimen is scanned by a beam of electrons that are reflected to form an image.

Scanning Electron Microscopy (SEM)-A type of electron microscope that produces images of a sample by scanning it with a focused beam of electrons.

Scavenging- the process of pushing exhausted gas-charge out of the cylinder and drawing in a fresh draught of air or fuel.

Screening- A technique used to identify and select for individuals who possess a phenotype of interest in a mutagenized population.

Seaweeds- refers to several species of macroscopic, multicellular, marine algae.

Secondary metabolites- Secondary metabolites are organic compounds that are not directly involved in the normal growth, development, or reproduction of an organism.

Semiquinone- is a free radical resulting from the removal of one hydrogen atom with its electron during the process of dehydrogenation of a hydroquinone.
Silane- any of various compounds of hydrogen and silicon that have the general formula Si_nH_{2n+2} and are analogous to alkanes.
Soil erosion- the wearing a way of topsoil. Topsoil is the top layer of soil and is the most fertile because it contains the most organic, nutrient-rich materials. One of the main causes of soil erosion is water erosion, which is the loss of topsoil due to water.
Sonicator- Any device that produces high-intensity ultrasound.
Species - a set of animals or plants in which the members have similar characteristics to each other and can breed with each other.
Spectrophotometer- an apparatus for measuring the intensity of light in a part of the spectrum, especially as transmitted or emitted by particular substances.
Spectrophotometrical - an instrument for making photometric comparisons between parts of spectra.
Staining- mark with colored patches or dirty marks that are not easily removed.
Stationary phase- The solid or liquid phase of a chromatography system on which the materials to be separated are selectively adsorbed.
Strain- a group of presumed common ancestry with clear-cut physiological but usually not morphological distinctions.
Supernatant- denoting the liquid lying above a solid residue after crystallization, precipitation, centrifugation, or other process.
Supernatant- denoting the liquid lying above a solid residue after crystallization, precipitation, centrifugation, or other process.
Surface Plasmon Resonance (SPR) -The resonant oscillation of conduction electrons at the interface between a negative and positive permittivity material stimulated by incident light.
Suspension cells- a type of culture in which single cells or small aggregates of cells multiply while suspended in agitated liquid medium.
Sustainable energy- energy consumed at insignificant rates compared to its supply and with manageable collateral effects, especially environmental effects.

T
Tannic acid- a reddish acid that comes from plants.
Thin layer chromatography- a chromatography technique used to separate non-volatile mixtures.

Thylakoids -any of the membranous disks of lamellae within plant chloroplasts that are composed of protein and lipid and are the sites of the photochemical reactions of photosynthesis.
Transesterification - a reaction between an ester of one alcohol and a second alcohol to form an ester of the second alcohol and an alcohol from the original ester.
Transesterification- the process of exchanging the organic group R″ of an ester with the organic group R′ of an alcohol. These reactions are often catalyzed by the addition of an acid or base catalyst.
Transmission Electron Microscopy (TEM)-A microscopy technique in which a beam of electrons is transmitted through an ultra-thin specimen, interacting with the specimen as it passes through it.
Triacylglycerols- an ester derived from glycerol and three fatty acids (tri- + glyceride). Triglycerides are the main constituents of body fat in humans and other animals, as well as vegetable fat.
Trichomes -a filamentous outgrowth.

U
Ultrasonic- involving sound waves with a frequency above the upper limit of human hearing
Undulated- having a wavy surface, edge or markings
UV-Vis spectroscopy- The measurement of the attenuation of a beam of light after it passes through a sample or after reflection from a sample surface. Absorption measurements can be at a single wavelength or over an extended spectral range.

V
Volatile- relatively vaporizable at a relatively low temperature

W
Wet nanotechnology- involves working up to large masses from small ones. Wet nanotechnology requires water in which the process occurs.